Technical Brief—Scanners

EPSON®

This technical brief provides detailed information on the Image Quality, Performance, and Flexibility of Epson Scanners.

▼ Image Quality—Factors affecting image quality

When comparing scanners, hardware resolution and color pixel depth are two features often used to gauge image quality. These two features are important, but there are a number of factors that determine image quality in a scanner, such as the following: (Many of these elements will be discussed in detail in upcoming sections of this document.)

Precision stepper motor for high quality sub-scan resolution

Optical resolution and color bit depth

Quality of the Analog to Digital converter (ADC); Epson scanners have optimum performance for minimal noise and tight color registration.

Dynamic range control

Type of lamp system used

Type of focus method

Optic system

Color vs. monochrome CCD

The Epson Expression® and GT series scanners are Epson's professional series scanners designed for excellence with respect to image quality, speed, usability, versatility, and durability. These scanners include the highest quality components.

The Epson Perfection® series scanners are designed for home and entry-level corporate and graphics arts users, and are designed with the highest quality components in their price class.

▼ Image Quality—Resolution

A scanner's resolution determines the amount of data that is read by the scanner. As resolution increases, so does the file size. Resolution is measured in a variety of ways.

1. **Optical resolution:** This is the actual number of pixels read by the CCD (Charge Coupled Device), which measures the intensity of the light that is reflected from the image to be scanned, and converts it to an analog voltage. If a scanner has a resolution of 600 x 2400 dpi, its optical resolution is 600 dpi, which means that it can resolve 600 bits of data per inch.

2. **Hardware resolution:** Using a precision stepper motor to double-step or quadruple-step the carriage, the scanner's sub-scanner resolution can be increased. For example, a scanner can have an optical resolution of 1200 dpi, but a hardware resolution of 1200 x 2400 dpi (because it double-steps the carriage to increase the vertical resolution).

1200 dpi

2400 dpi

▼ Image Quality—Resolution (cont.)

3. Interpolated resolution: Interpolation is a method to increase the resolution of an image. It uses a complex algorithm to "add" pixels to an image based on the mathematical probability of surrounding pixels.

For example, if a scanner has a hardware resolution of 1200 x 2400 dpi, and a maximum resolution of 9600 x 9600 dpi, the scanning software uses interpolation to create scanned images with resolutions greater than the hardware resolution.

4. Benefits of higher optical resolution: Higher resolution allows you to scan the following types of images without using interpolation. Using actual image data instead of interpolated data results in more accurate images.

	Line Art When scanning black and white line art, image pixels translate exactly to the printed dots. Therefore, high resolution is required to capture and print the sharp lines and edges of an image.
2 x 2.5 inch image scanned at 1200 dpi — If enlarged to 8 x 10 inches, effective resolution: 300 dpi	**Enlarging a small original** In order to capture enough detail to enlarge an image, you must increase the scanned resolution in proportion to the increase in image size. If you don't, then you will have to interpolate image data to maintain the same resolution in the larger image.
	Precise pixel editing Many graphic artists scan images at high resolutions for precise pixel editing. It is always better to capture the image data when the image is being scanned and use true image data than to use interpolation if more data is needed later.

▼ Image Quality—Pixel depth

Pixel depth refers to the number of bits of data captured for each picture element (pixel). Each pixel can have two states (On or Off); therefore the number of colors or gray scales that a scanner can recognize is computed by taking the pizel depth as an exponent of two. The following charts lists the number of colors recognized for each different scan mode.

Scan mode	Number of colors recognized
Bi-level (1 bit per pixel)	2^1 = 2 colors (black and white)
8-bit gray scale	2^8 = 256 shades of gray
10-bit gray scale	2^{10} = 1,024 shades of gray
8-bit color (indexed color)	2^8 = 256 colors
24-bit RGB (8 bits per pixel, per color)	2^{24} = 16.7 millions colors
36-bit RGB (12 bits per pixel, per color	2^{36} = Over 68 billion colors
48-bit RGB (16 bits per pixel, per color)	2^{48} = Over 250 trillion colors

▼ Image Quality—Pixel depth (cont.)

All Epson scanners have a 42-bit or 48-bit color depth. but some of the models support 24-bit external color depth, which is the data that is sent from the scanner to the computer. Here are the differences between output color depth:

Key Differences	42-bit, or 48-bit Internal/ 24-bit External Color Depth	36-bit, 42-bit, or 48-bit Internal and External Color Depth
How it works	The scanner captures 42-, or 48-bit image data, but "downsamples" an image to 24-bits, keeping the most significant color data. 48-bit capture 24-bit transfer	The scanner captures 36-, 42-, or 48-bit image data and outputs all data to a software aplication that supports 48-bit image files (such as Adobe® Photoshop®). 48-bit capture 48-bit transfer
Image quality	Because the scanner captures data that never could have been read by a 24-bit or 30-bit scanner (such as the detail in dark areas and slight color transitions), the scanner delivers more accurate images	With a 48-bit image file, you always have access to full image data, which is especially important to graphic artists and designers.

A greater color bit depth generally results in more accurate color reproduction, smoother gradations with fewer sudden shifts in color, and detailed shadows and highlights.

▼ Image Quality—Epson ColorTrue® Imaging System

Epson scanners use the Epson ColorTrue II Imaging System which is made up of three main elements (hardware, optics, and processing) and result in superior image quality with fast processing speeds.

Precise scan carriage
Simultaneous RGB scanning

High resolution CCD
Custom glass lenses

Pixel optimization
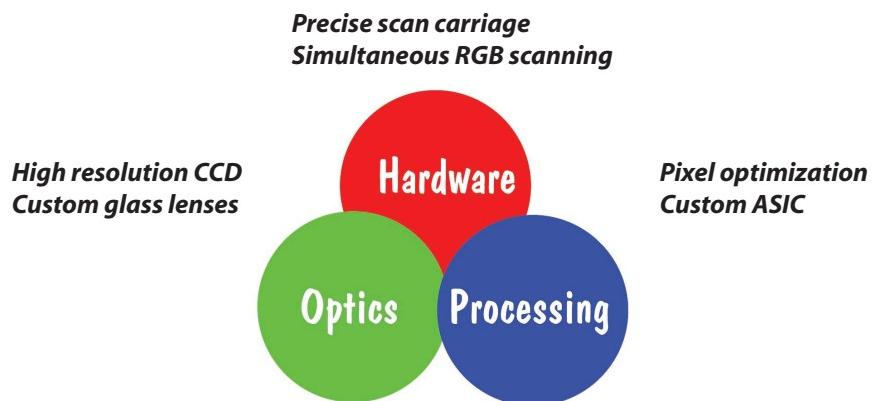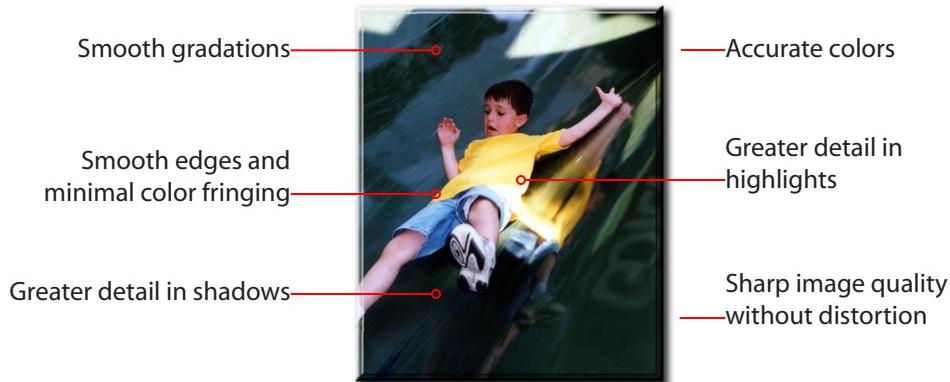*Custom ASIC*

Hardware

Optics

Processing

## ▼ Image Quality—Epson ColorTrue® Imaging System (cont.)

Through a combination of these hardware, optics, and processing features, the Epson ColorTrue Imaging System and Epson ColorTrue II Imaging System deliver scanned images with:

Smooth gradations ——————

Smooth edges and minimal color fringing ——————

Greater detail in shadows ——————

—————— Accurate colors

—————— Greater detail in highlights

—————— Sharp image quality without distortion

1. Hardware components: Epson scanners use a precise scan carriage with better motors to achieve subscan resolutions that are double or quadruple the scanner's optical resolution. Additionally, Epson scanners capture Red, Green, and Blue simultaneously, versus other scanners that use one-pass scanning but alternate Red, Green, and Blue lights for each line of a scan. Epson advantages are:

- ▼ Better color registration
- ▼ Faster scanning speeds
- ▼ Higher quality sub-scan resolutions

Epson Method
(1/2 or 1/4 step carriage movement)

Simultaneous RGB Capture

One pass
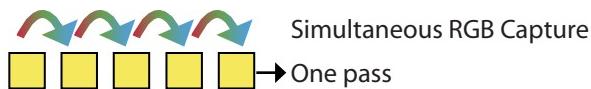
Single-Pass Alternate RGB Method
(1/2 step carriage movement)

Red Capture

Green Capture

Blue Capture

One pass
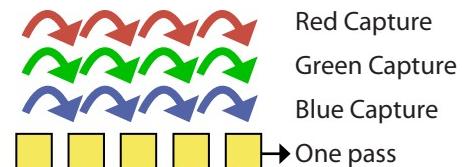
2. Optics: Epson scanners use custom lenses that are designed specifically to work with Epson technology and the scanner's CCD. These lenses feature:

- ▼ Larger "sweet spot" and precision lenses for reduced distortion
- ▼ Accurately aligned lens elements to control sharpness
- ▼ Glass lenses (versus plastic lenses used by many competitors) which offer better reflective qualities, providing greater image quality.
- ▼ Better image quality than competitive off-the-shelf lenses because Epson scanners feature custom-made lenses that match the CCD.
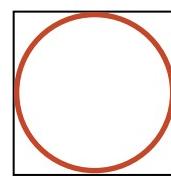
Small "sweet spot" can allow edge distortion
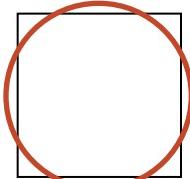
Larger "sweet spot" minimizes distortion

▼ Image Quality—Epson ColorTrue® Imaging System (cont.)

3. Processing: Many Epson scanners use a custom ASIC (Application Specific Integrated Circuit) for fast scanning. Key features include:

- ▼ Line correction captures and processes full RGB color for every pixel and minimizes color fringing in subscan direction.
- ▼ Zoom capability enables smoothest edges along diagonal or curved lines and achieves higher interpolated resolution
- ▼ On-board memory allows for Auto Area Segmentation (AAS) and Text Enhancement Technology (TET) processing within the scanner—AAS and TET are independent from PC or Macintosh processing, allowing the scanner to work with better "raw" data.

Additionally, Epson scanners have a pixel optimization feature that uses the full resolution of the scanner's CCD, even scanning at a lesser resolution. The benefit of this feature is truer image quality.

- ▼ For example, on one of the Epson 600 dpi Perfection scanners, when scanning an image at 300 dpi, the scanner still uses all 600 pixels per inch to scan the image, then averages the data to yield the lower resolution image.
- ▼ Some competitive models lower resolution by turning off some pixels to capture less image data.

Epson Method:

600 dpi

300 dpi — Average   Average   Average

Competitive Method:

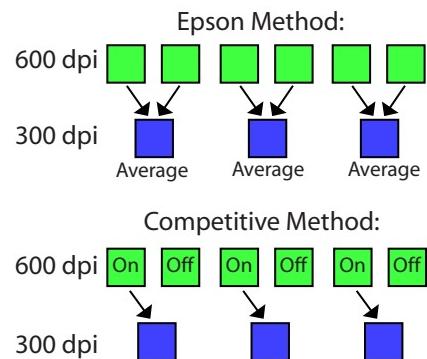600 dpi — On Off   On Off   On Off

300 dpi

▼ Image Quality—Color CCD

All Epson scanners use a color CCD which uses a single white light source, instead of a monochrome CCD and three light sources. The color CCD results in faster scanning speeds and the ability to scan three-dimensional objects without producing color "ghosts."
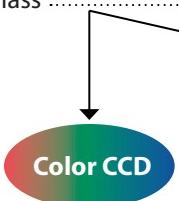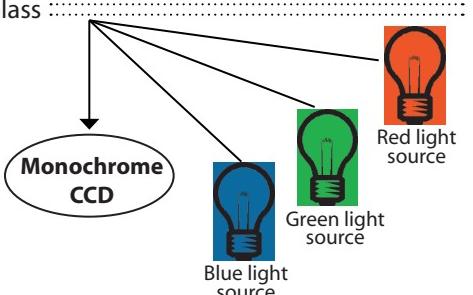
Key Differences	Color CCD	Monochrome CCD
How it works	Red, green, and blue are quickly captured in the color CCD illuminated by a single light source. Glass ::::::::::::::::::::::::::::::::::::::: Color CCD — White light source	three separate lamps are fired for eachline of a scan, slowing the scanning speed. Glass ::: Monochrome CCD — Red light source / Green light source / Blue light source
Result when scanning three-dimensional objects	Single light source allows precise alignment when scanning non-flat surfaces	The three lamps can cause misalignment when reflected from non-flat surfaces.

▼ Image Quality—Dynamic Range

Dynamic range measures the difference between the lightest highlights and darkest shadows that a scanner can perceive (on a scale of 3.0 to 4.0). The maximum density rating is referred to as Dmax.

A dynamic range measurement is important for designers who scan transparent media (such as slides, transparencies, and negatives) because the media itself generally has a dynamic range of 3.2. Reflective media, such as a photograph, generally does not have a dynamic range greater than 2.0.

▼ A high dynamic range results in scanned images with superior detail in highlights and in shadows— especially when scanning transparent media.
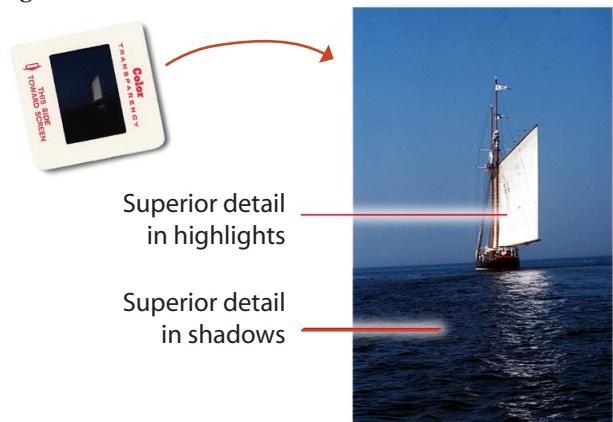
Superior detail in highlights

Superior detail in shadows

▼ Image Quality—Focus Method

Epson scanners use a fixed focus system, AutoFocus optics system, or a Dual-Focus mechanism.

1. **Fixed Focus:** With this type of focus system, the lens is set to record everything sharply from a fixed distance— from the lens to the glass scanning bed. The Epson Perfection and GT series scanners use a fixed focus optics system. The newest Epson scanners have a fixed focal point just above the surface of the glass for optimized film scanning.

2. **AutoFocus optics system:** Epson highest-end graphic arts scanners use an AutoFocus optics system that can be used in AutoFocus mode or manual mode. This system offers these benefits:

Epson automatic/manual focus

▼ The Epson manual/automatic focus optics system gives you precised sharpness control, especially when scanning three-dimensional objects and transparencies.

▼ With three-dimensional images, you can pick your point of focus so that background items are captured with sharp detail, as shown in the glove and towel in the images to the right.

Standard fixed focus

▼ For super sharpness when scanning transparencies or slides mounted in holders, you can set the focus to compensate for the 2.5mm distance between the glass and the slide.

3. **Dual-Focus mechanism:** One of the Epson Expression series scanners uses a Dual-Focus mechanism. When using the scanner's custom film holders to scan transparent media, you can set the scanner's focal distance to compensate for the 2.5mm distance between the glass and the media. This method eliminates the "Newton Ring" problem that plagues less sophisticated scanners. Newton Rings are the circular rainbow-colored patterns that appear in a scanned image, caused by surface tension. This effect is similar to the rainbows that appear in soap bubbles.
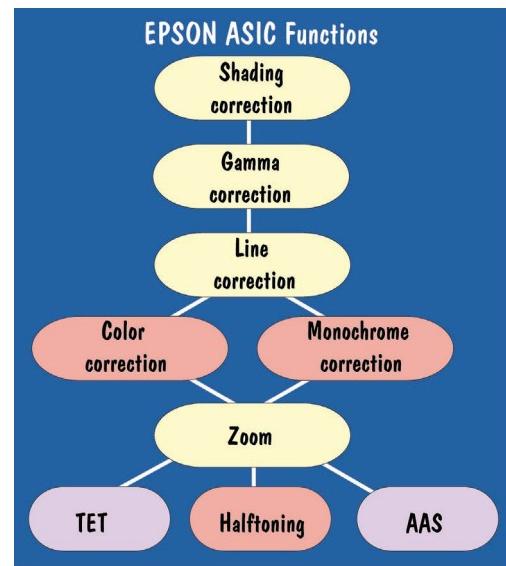
▼ Image Quality—Light Source

The Epson Perfection series scanners use a Cold Cathode Fluorescent Lamp (CCFL) and the Expression series scanners use a Xenon Cold Cathode Lamp. These lamps have unsurpassed reliability and longevity because heat is not used. The advantages of a Xenon Cold Cathode Lamp over a Cold Cathode Fluorescent are:

- ▼ Shorter lamp warm-up time, which means that you can get accurate scans as soon as you turn the scanner on (and this also translates to faster speed).
- ▼ Longer durability at a higher price
- ▼ Produces more natural-looking colors because it more closely resembles natural sunlight.
- ▼ Cold Cathode Fluorescent Lamps can also exhibit color casts towards reddish/magenta or bluish depending on whether they tend to run hotter or cooler. Xenon lamps have less variances.

▼ Performance—Hardware Processing

Many Epson scanners use an advanced image processing ASIC (Application Specific Integrated Circuit) that results in fast scanning speeds. This custom ASIC quickly and accurately controls the functions shown.

EPSON ASIC Functions
- Shading correction
- Gamma correction
- Line correction
- Color correction
- Monochrome correction
- Zoom
- TET
- Halftoning
- AAS

▼ Performance—Batch Scanning

Epson scanning software supports batch scanning:

- ▼ Without batch scanning, you must scan each image separately.
- ▼ With batch scanning you can define customized settings for each framed original, then capture each one as a separate file—all with one scan.

Place originals on the scanning bed

Select and define frames in the scanner driver, and scan!

▼ Performance—High-Performance Interfaces

In general, Epson scanners targeted to home and small office users have a USB interface for maximum ease of use. Epson scanners targeted to corporate and graphic arts uses have USB and/or SCSI-2 interfaces for maximum performance. An optional interface for some scanners is the IEEE-1394 (FireWire®) interface.

The key differences between the scanner interfaces are:

Key Differences	USB 1.1/2.0	SCSI-2 narrow/wide	FireWire
Macintosh connection	Direct connection to USB-ready Macintosh computers	Direct connection to SCSI port or installed Fast SCSI PCI interface card	Direct connection to FireWire-ready Power Macintosh computers and to any PCI Macintosh with an Apple® FireWire Kit
PC connection	Direct connection to USB port	Requires Fast SCSI PCI interface card	Direct connection to FireWire port or an installed FireWire card
Daisy chaining	Yes, up to 127 devices via USB hub	Yes, up to 8 devices	Yes, up to 63 devices
Hot plugging*	Yes	No	Yes
Performance (MegaBytes per second)	Up to 1.5/60 MBps	Up to 10/20 MBps	Up to 50 MBps

* Hot plugging allows you to attach or detach the cable without powering off/on the scanner or computer.

Most Epson scanners that include a USB port offer the newer USB 2.0 (Hi-Speed USB).

- ▼ Hi-Speed USB is backward compatible with USB 1.1, so if you have an older computer with a USB port, it will work with a new Epson scanner.
- ▼ You will see only the highest speeds on your scanner if you have a Hi-Speed USB port on both your computer and your scanner.

▼ Flexibility—Intelligent Negative Scanning

With a transparency unit attached, Epson scanners can scan color negatives (such as 35mm negative strips) and convert them directly to positive images.

- ▼ Some other scanners can only scan positive transparent media, such as color transparencies and slides.

Negative   Positive

to
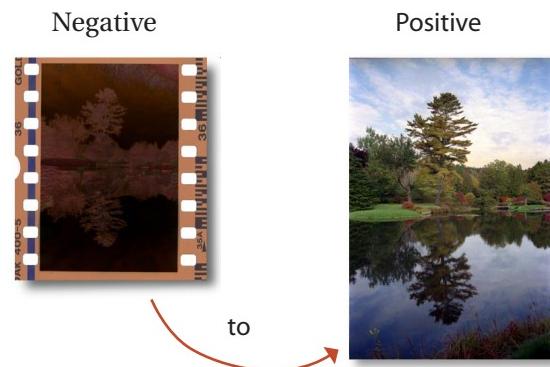
▼ Flexibility—Network Scanning

Newer networkable Epson scanners offer the ability to connect to the network as a device (through a network card) and don't have to connect through a specific scan server.

Some other Epson scanners can be shared over a network, using the following procedure:

- ▼ Attach the scanner to a single computer on the network.
- ▼ Install Epson Scan Server (Windows only) on that computer.
- ▼ Install the Epson TWAIN Pro Network scanner driver on all computers that will access the scanner over the network.

▼ Flexibility—Special Document Scanning Features

Many of the Espon scanners support Text Enhancement Technology and Auto Area Segmentation for additional control when scanning text documents and mixed text and graphics documents. These features are available through the Epson Scan or Epson TWAIN Pro driver when scanning in binary (black and white) mode.

1. **Text Enhancement Technology (TET):** This feature improves recognition accuracy when you are scanning a document to be processed using OCR (Optical Character Recognition) software which will convert the scanned image into a text documentation on your computer. TET has two advantages:

- ▼ Accurately recognizes text on a colored background
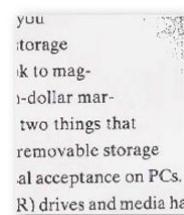- ▼ Accurately recognizes text surrounded by "noise."
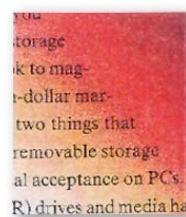
Original document   OCR result without TET   OCR result with TET

2. **Auto Area Segmentation (AAS):** This feature is ideal when scanning a document that contains both text and images that you wish to fax or print. It produces readable text and improved image quality in a binary (black and white) scan.

With AAS:

| Scan mode	Image result
Binary— Entire page is captured in back and white, and text can be processed by OCR software	

Without AAS:

Scan mode	Image result
Binary— Page is captured in black and white, but image is halftoned to look like a gray scale. Text can be processed by OCR software.	

▼ Flexibility—Epson Scan

Epson Scan software differs slightly by scanner model. Different scanners offer three of these four distinct scan modes to meet the needs of novice, intermediate, advanced, and business users.

▼ **Full Auto Mode:**
For the novice user—Epson Scan automatically previews the images and recognizes the document source and type. This mode then automatically crops, uses the auto-exposure settings to optimize images, and scans the image.
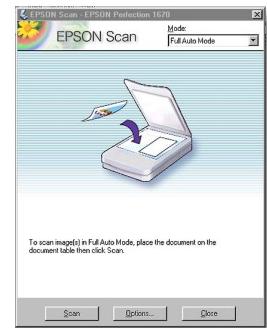
Full Auto Mode

▼ **Home Mode:**
For the intermediate user—allowing adjustments of the basic image settings. Icons represent common scan settings. Available options include automatic sizing, one-touch color restoration, brightness and contrast adjustment, and destination/resolution choices. This mode allows the advanced amateur to select the best of automated features and user-controlled settings.
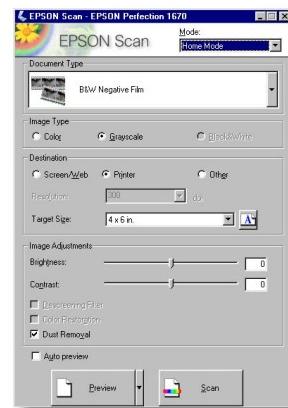
Home Mode

▼ **Professional Mode:**
For the advanced user—many options are available to give you greater control over your scanning. This mode allows the advanced user to have complete control over many sophisticated elements of pre-scanning. These elements include the Densitometer (a tool that allows a user to hit a specific color via numerical data), Multiple Marquee (for batch scanning), and Histogram (to correct tonal distribution).
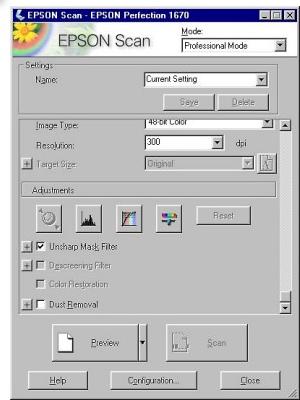
Professional Mode

▼ **Office Mode:**
For the business user—the Office Mode is helpful when you need to scan a large number of documents with the same size, using the optional Automatic Document Feeder. You can scan documents easily and quickly without preview in this mode.
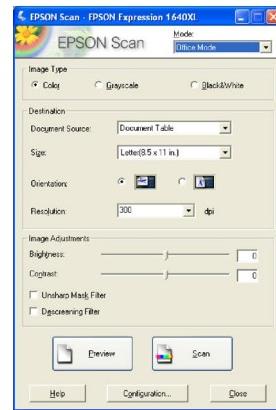
Office Mode

▼ Flexibility—Epson Scan with Epson Easy Photo Fix™ Scanning Software

Epson Easy Photo Fix technology is a combination of powerful elements included in the latest Epson Scan driver:

▼ Epson exclusive **One-touch Color Restoration** instantly (with just one click!) restores faded and discolored photographs, slides and negatives.

Original   Color corrected

▼ Epson **Dust Removal** instantly cleans up slides and negatives — with just one click!


Original   Dust removed and color corrected

▼ Epson Scan **Grain Reduction** smooths the grain that is sometimes evident at high scanning resolutions. When you scan a slide or film at a high resolution, the scanner is sensitive enough to pick up the slight shadows created by the indifical crystal structures in the emulsion. When you choose Grain Reduction in the Epson Scan driver, the driver uses a slight blur effect to smooth out the grain.

▼ Flexibility—DIGITAL ICE™ technology from Applied Science Fiction™

DIGITAL ICE technology from Applied Science Fiction(ASF™) is a scanner feature that combines hardware and software to remove dust and scratches on film and remove tears, folds, creases, and deep scratches on photos. This feature is not available on all Epson scanners.
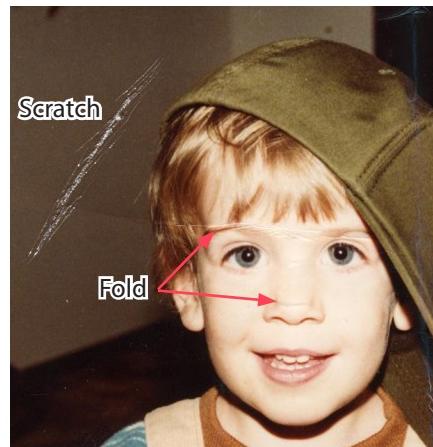
Color photo before DIGITAL ICE   Color photo after DIGITAL ICE

▼ Flexibility—LaserSoft Imaging™ SilverFast® Scanning Software

Some Epson scanners include LaserSoft Imaging SilverFast in addition to Epson Scan scanning software. Many of the Epson high-end scanners include different versions of this powerful scanning plug-in for Adobe® PhotoShop®. The specific driver varies by scanner model (refer to the product reference materials for details), but the general key features to the driver are:

- ▼ It includes sophisticated color correction functions that can be applied during the scan process to manipulate full 36-bit color data.
- ▼ It supports up to 48-bit color image file types.
- ▼ It displays realtime effects of each setting in the Preview window.
- ▼ It supports scanning in RGB, CMYK, and L*a*b modes.

▼ Flexibility—Epson Smart Panel™ software

EPSON Smart Panel allows you to scan and send data directly to an assigned application or to the EPSON photo-sharing site. You can also obtain photos and documents in digital form quickly and easily.

This version of the Epson Smart Panel includes the following features:

- ▼ RePrint Photos
- ▼ Scan and Save
- ▼ Copy Center
- ▼ Edit Text
- ▼ Business Card
- ▼ Scan for Creativity
- ▼ Scan to Application
- ▼ Scan to E-mail
- ▼ Epson Photo Site

When you click on **RePrint Photos**, the Epson Photo Print Utility launches. You can use this application to scan and then print images as photos. You can print in various sizes, or place several photos on the same page. You can also create collages or print several versions of the same image easily.